

**SINTEF Applied Chemistry**

Address: N-7465 Trondheim,
NORWAY
Location: S.P. Andersens vei 15A
Telephone: +47 73 59 20 80 / 12 12
Fax: +47 73 59 70 51

Enterprise No.: NO 948 007 029 MVA

SINTEF REPORT

TITLE

Users Manual
Minerals Management Service
Pipeline Oil Spill Volume
Computer Model

AUTHOR(S)

Mark Reed, May Kristin Ditlevsen, Ben Hetland, Morten Haug
Emilsen, Øistein Johansen, Boye Høverstad

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U.S. Minerals Management Service
Herndon, Virginia USA

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ABSTRACT

The Pipeline Oil Spill Volume Computer Model (POSVCM) provides a methodology to estimate discharges from seafloor pipelines. The system is composed of a Release Module and a Nearfield Module, linked together with necessary databases through a Graphical User Interface (GUI). This document describes the use of POSVCM. Inputs to the model are parameters describing the configuration and characteristics of a pipeline system, the fluid it contains, and the leak or break from which the discharge occurs. Key outputs are the evolution of the release rate over time, the total mass of oil released, and a measure of the mean thickness of any eventual surface slick being formed.

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1 Introduction

The Pipeline Oil Spill Volume Computer (POSVCM) provides a methodology to determine worst-case discharges from seafloor pipelines. Inputs to POSVCM are parameters describing the configuration and characteristics of a pipeline system, the fluid it contains, and the leak or break from which the discharge occurs. Key outputs are the evolution of the release rate over time, the total mass of oil released, and a measure of the mean thickness of any eventual surface slick being formed. The system is composed of a Release Module and a Nearfield Module, linked together with necessary databases through a Graphical User Interface (GUI).

Limitations of application are:

- Single “tree” network” with all branches (pipelines) converging toward a single outlet point at its root;
- No closed re-circulating loops;
- One and only one leakage point;
- Maximum of 100 pipeline segments per branch (i.e. between junctions) and 5 junction points;
- Maximum of 5 pipeline segments attached to a single junction;
- Only pipeline objects may connect directly to nodes (i.e. junctions or connectors);
- Pipeline objects must connect to non-pipeline objects at both ends;
- Maximum of 50 branches (series of Pipeline objects between junctions);
- Connection object connects exactly two pipeline objects;
- Junction object connects at least 3, and not more than 10 pipeline objects;
- An Inlet must be at the start of an incoming branch;
- Outlet object must connect to only one incoming pipeline object;
- Leakage point must be attached to a Pipeline object
- Diameter of leak cannot exceed pipe diameter. (This is checked and corrected automatically in the Release Module.)

Necessary inputs for simulation of a given scenario are:

- Fluid properties:
 - Oil density
 - Gas density (can default to 1 kg/Sm³)
 - Gas-Oil Ratio
 - Percent water in fluid
- Flow inlet properties:
 - Depth (positive down; negative above mean sea level)
 - Total liquid flow rate (oil plus water plus gas)
 - Fluid temperature
 - Closing (or shut-in) time
- Pipeline or riser segment
 - Length
 - Inside diameter
 - Roughness coefficient (can default to 5.0×10^{-5})
 - Heat transfer coefficient (can default to 1 J/s)
 - Ambient temperature
- Pipe connector or junction
 - Depth
- Outlet (to remainder of pipeline system or storage)
 - Depth

- Fluid pressure
- Closing (or shut-in) time
- Leak properties
 - Distance from upstream endpoint
 - Nominal diameter (not larger than pipeline diameter)
 - Water depth.

1.1 Installation

Insert the CD and run setup.exe to install the program. Double-click the POSVCM.exe file and the main window appears with an empty work desk, Figure 1.1.

Click objects on the toolbar and click again on the work-desk to construct a diagram of the pipeline system of interest. When the diagram is printed or saved, the contents of the work-desk will be saved.

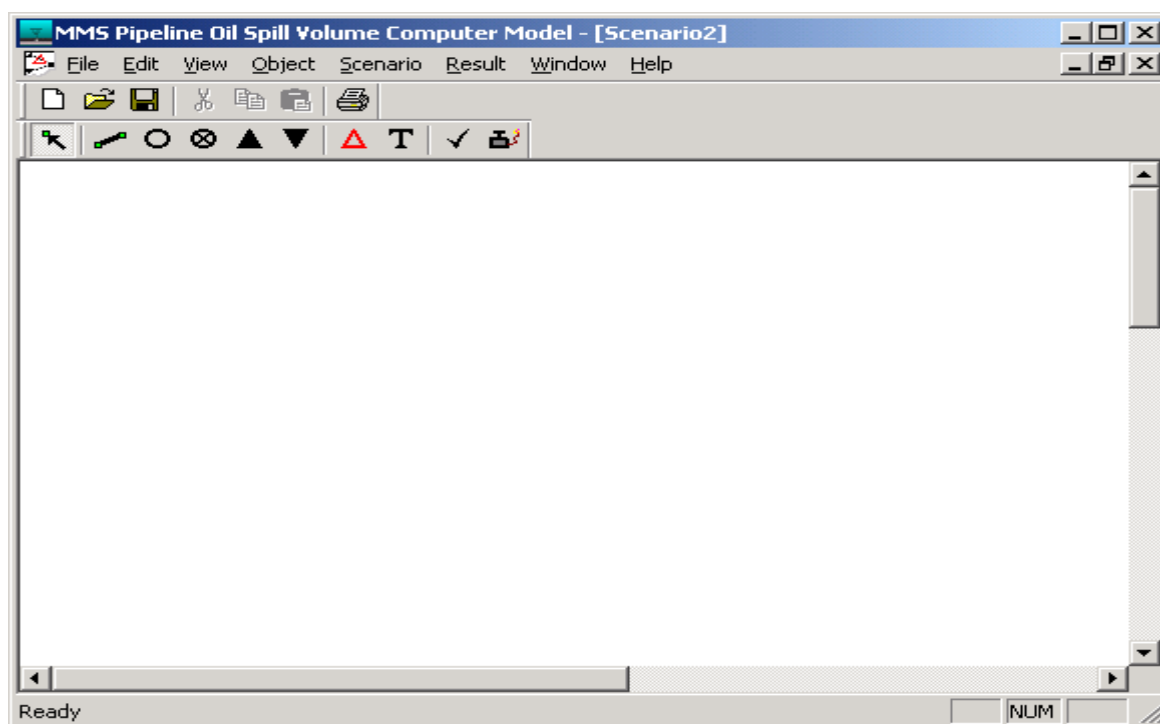
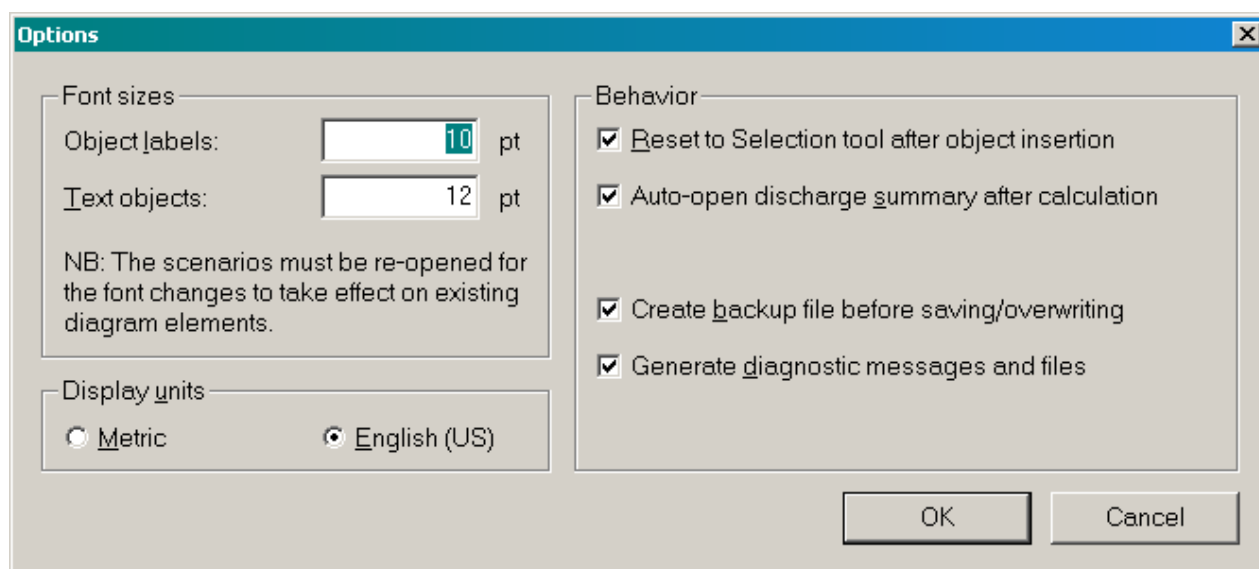


Figure 1.1 Main window for The Pipeline Oil Spill Volume Computer Model (MMS-POSVCM).

1.2 User options and view control

User options, including text size and font, and English or metric units, are set in the View>options menu.

To zoom in or out on a scenario sketch, use the F10 or F9 function keys, or the menu items View>zoom.



1.3 Create a new scenario

A scenario consists of a constellation of connected objects, each of which is assigned a set of parameters. Under the Object menu or on the object toolbar one has six objects from which to choose:

- Pipeline
- Connection
- Junction
- Inlet
- Outlet
- Leakage

The parameters defining each object are given in Table 1.1.

Object	Parameters				
Pipeline Segment	Length	Diameter	Roughness	Heat Transfer Coefficient	Ambient Temperature
Connector	Depth				
Junction	Depth				
Inlet (Flow Source)	Depth	Flow Rate	Fluid Temperature	Closing (or Shut-in) Time	
Outlet (Flow Sink)	Depth	Pressure			
Leak Point	Distance from upstream endpoint	Nominal Diameter	Depth at leak location	Back Pressure	

Table 1.1 Parameters defining objects in a discharge scenario.

Choose the component you want to place on your work desk, and click it into the work area.

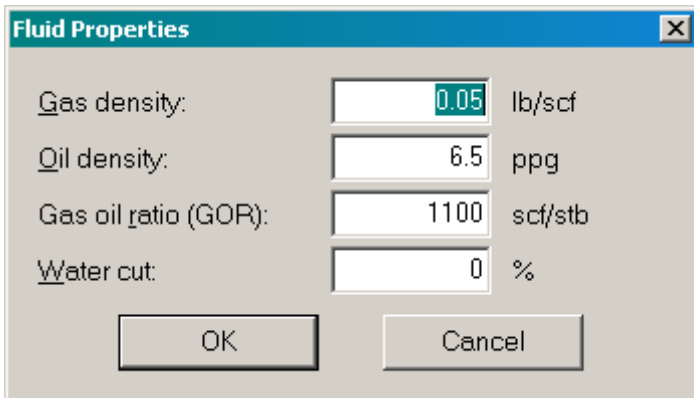
When a pipeline segment or leak point is inserted into the work area, it will appear with small green boxes defining the connection points. Pipeline segments can be resized by dragging one of these green boxes. Objects can be moved on the work-desk by click-and-drag.

To delete an object, click on the object and press the Delete key (or use the Delete command under the Edit menu).

All objects must be connected together before a scenario will run. Pipelines and Leak Points can connect to Connectors, Junctions, Inlets, and Outlets at any of their blue connection markers. The green box in the center of the Leak Point, or at the end of the Pipeline segment, will turn red when the connection has been properly made.

To verify that a connection has been properly made, click and drag the Connector, Junction, Inlet, or Outlet (not the Pipeline Segment or Leak Point), and see that the attached object(s) follows after. (Clicking on the pipeline element will detach it from its connectors and junctions.)

Set the fluid properties under the Scenario menu item:



Fluid Properties

Gas density: lb/scf

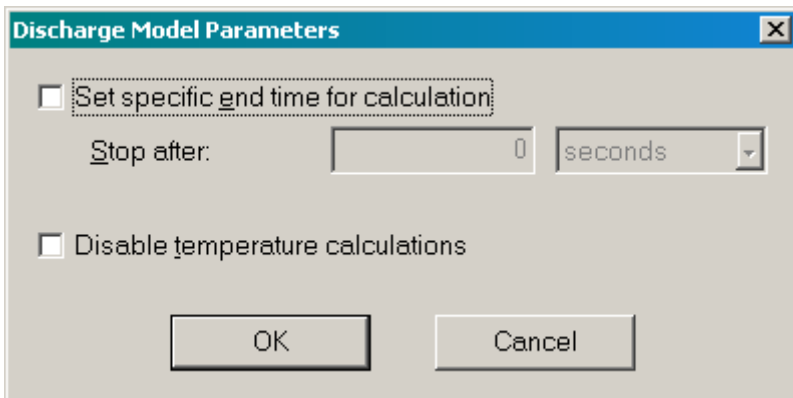
Oil density: ppg

Gas oil ratio (GOR): scf/stb

Water cut: %

The Discharge model parameters, also under the Scenario menu item, allow the user to extend or shorten the time period to be simulated. This is useful, for example, when making short test runs of a new scenario.

The temperature calculations can also be disabled here, to facilitate computation of complex scenarios that may introduce instabilities into the multi-phase release module.



Discharge Model Parameters

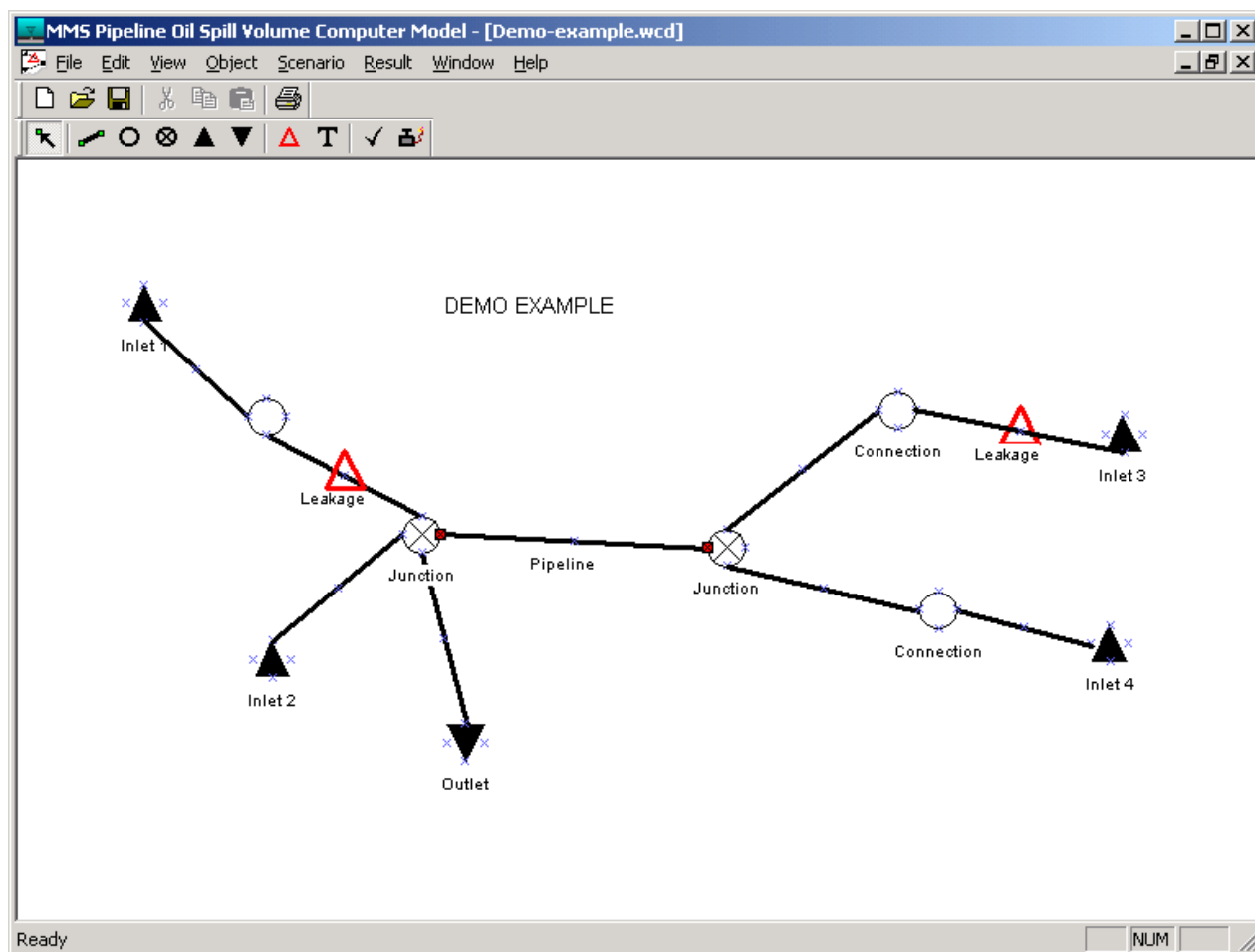
☐ Set specific end time for calculation

Stop after:

☐ Disable temperature calculations

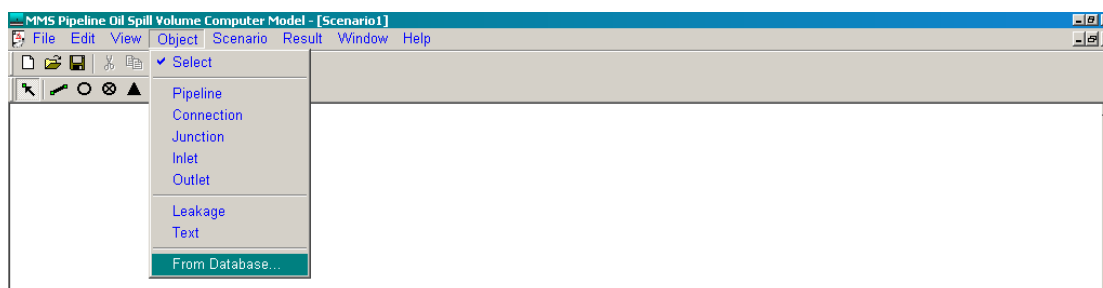
Notes:

1. When opening an existing scenario, some pipelines may appear to be disconnected from their junctions and connectors. This is a only visual effect resulting from the use of long text strings in names of elements, and does not affect the integrity of the scenario. These text strings mask the placement of objects. Simply click on the junctions and connectors, and the pipelines will return to their correct positions.
2. The layout on the desktop is generally not to scale. Only the parameters such as length and depth) allocated to each element in the diagram are used in the actual calculations. Moving an object manually on the desktop will not alter the basis for the computations in the POSVCM.

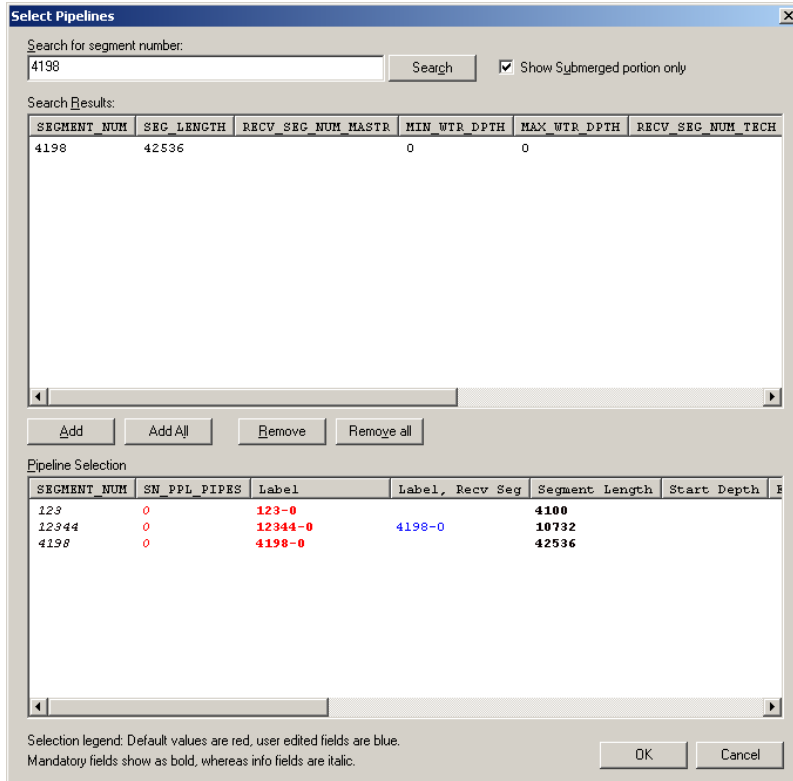


1.4 Using data from the MMS Pipeline Information Database

The POSVCM allows the user to draw data directly from the MMS Pipeline Information Database. To access the database, go to the menu item Object>From Database.



This brings up the Select Pipelines dialogue window:



Search for segment number:
4198 Search ☒ Show Submerged portion only

Search Results:

SEGMENT_NUM	SEG_LENGTH	RECV_SEG_NUM	MASTR	MIN_WTR_DPTH	MAX_WTR_DPTH	RECV_SEG_NUM	TECH
4198	42536			0	0		

Add Add All Remove Remove all

Pipeline Selection

SEGMENT_NUM	SN_PPL_PIPES	Label	Label, Recv Seg	Segment Length	Start Depth
123	0	123-0		4100	
12344	0	12344-0	4198-0	10732	
4198	0	4198-0		42536	

Selection legend: Default values are red, user edited fields are blue.
Mandatory fields show as bold, whereas info fields are italic.

OK Cancel

By entering the desired pipeline segment numbers in the top dialogue box and clicking Select (or the Enter key on the keyboard), segment numbers with associated data are collected in the upper half of the window (the “Search Results” window). Any or all of these may then be added to the active Scenario using the Add and Add All buttons between the top and bottom windows, or by double-clicking the desired segments. This will add segments to the current selection, shown in the lower half of the window (the “Pipeline Selection” window). Clicking OK closes the window, and places the selected pipeline segments in the active Scenario.

Data retrieved from the database for each pipeline segment include

- ID number,
- Length,
- Diameter and wall thickness (to compute inside diameter),
- Receiving segment number (to identify potential joins).

Other data, such as pipe grade and minimum and maximum water depths, are also retrieved, but are not used in the present version of the model. They are however displayed, in order to aid the user in selecting segments and editing data. For instance, minimum and maximum depth may give a hint to the start and end depth of a segment.

As described in the next chapter, a number of properties must be supplied for each pipeline segment. As far as possible, these are taken from the information in the database. Some data are however not available from the database, in which case the same default values as used elsewhere in the model are supplied.

Font and color coding is used in the selection window to indicate field status. Some fields are mandatory, meaning that they must be supplied for the model to be able to run correctly. These are shown in bold. Optional fields are in standard font, whereas info fields containing data that is not used in the model are in italics. The text color indicates the data source. System default is

used for data from the database, red is used for data supplied by the database module (e.g. default values), and user edited data is written in blue.

The user can edit field values by double-clicking the corresponding field. It is advised that the user consider editing data fields where default values are used for parameters central to the model, such as start and end depth.

Each selected pipeline segment is given a unique label. Labels are generated as [SEGMENT_NUM]-[SN_PPL_PIPES], but can be changed by the user after selection.

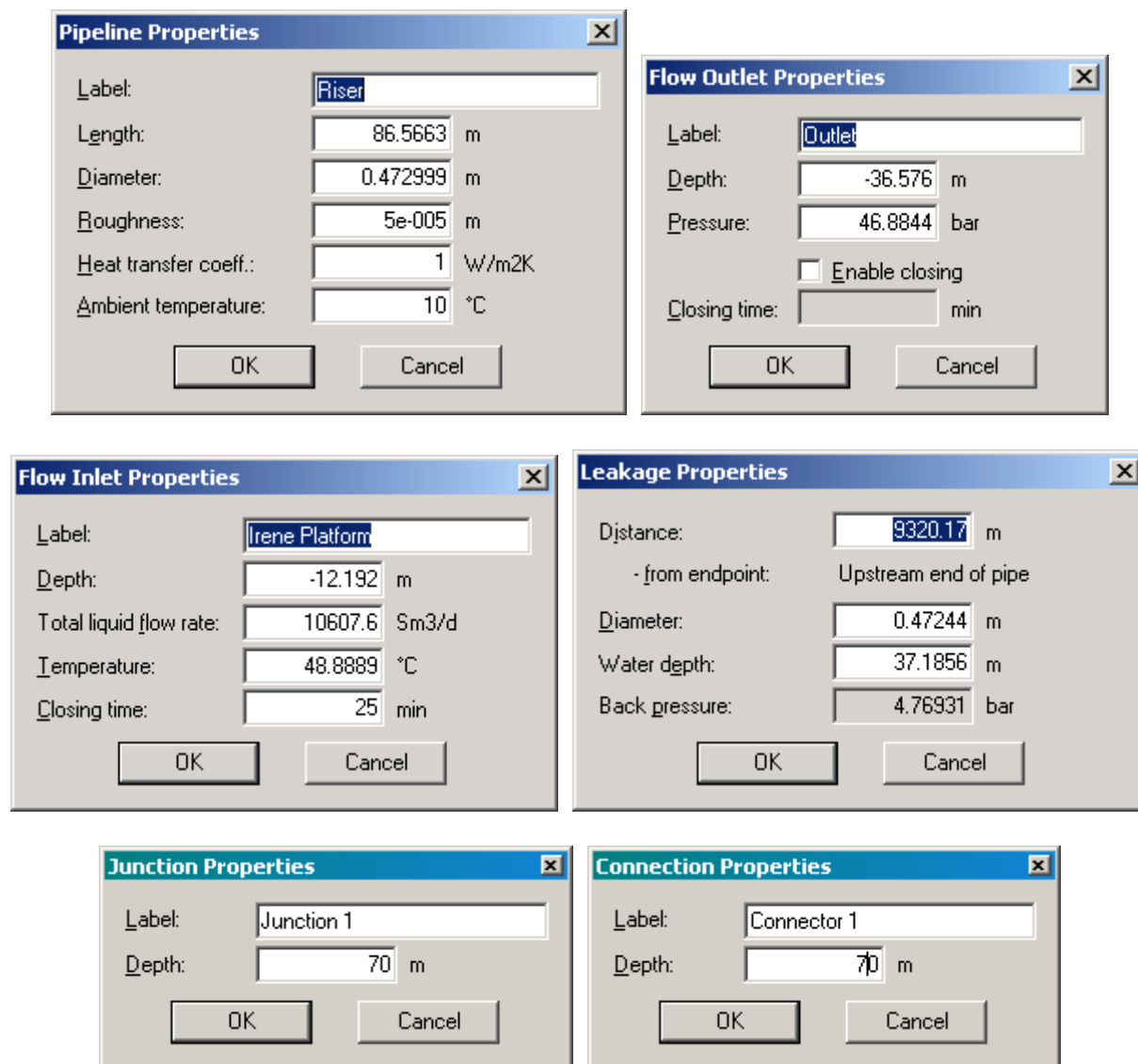
Pipeline segments can be connected by entering labels in the “Label, Recv Seg” field. This will create a joint between the two segments in the scenario. If either end depth of sending segment or start depth of receiving segment is specified, this will be used as the depth of their common joint. If both depths are given, depth of sender is used.

In some cases the database contains the segment number of the receiving segment. The user can then right-click the segment in the “Search Results” window and select “Search for receiving segment” from the drop-down menu to find the receiving segment. Note that the two segments are not automatically connected, this must be done by doubleclicking the “Label, Recv Seg” field of the sending segment and entering the receiving segment’s label.

All units are as in the main program when the user has selected to display “English (US)” units.

2 Object properties

After placing a selected object one has to supply required parameters. Right-click the object and choose Properties, or double-click and the Properties box appears. Fill in specifications for each object.



The figure displays five separate dialog boxes for configuring different types of objects in a simulation. Each dialog box has a title bar with a close button (X) and contains several input fields with labels and units, followed by OK and Cancel buttons.

- Pipeline Properties:**
 - Label: Riser
 - Length: 86.5663 m
 - Diameter: 0.472999 m
 - Roughness: 5e-005 m
 - Heat transfer coeff.: 1 W/m2K
 - Ambient temperature: 10 °C
- Flow Outlet Properties:**
 - Label: Outlet
 - Depth: -36.576 m
 - Pressure: 46.8844 bar
 - ☐ Enable closing
 - Closing time: min
- Flow Inlet Properties:**
 - Label: Irene Platform
 - Depth: -12.192 m
 - Total liquid flow rate: 10607.6 Sm3/d
 - Temperature: 48.8889 °C
 - Closing time: 25 min
- Leakage Properties:**
 - Distance: 9320.17 m
 - from endpoint: Upstream end of pipe
 - Diameter: 0.47244 m
 - Water depth: 37.1856 m
 - Back pressure: 4.76931 bar
- Junction Properties:**
 - Label: Junction 1
 - Depth: 70 m
- Connection Properties:**
 - Label: Connector 1
 - Depth: 70 m

Figure 2.1 Object properties input dialogs. Labeling objects is not required, but is recommended as an assist in locating problems with the scenario setup.

Standard suggested values for the heat transfer coefficient for carbon steel pipelines are as follows:

Insulation	Buried**	Heat Transfer Coefficient	
		W/m ² K	BTU/(ft ² h°F)
-	-		
None	No	50	10
10 mm PP*	No	17	3
20 mm PP*	No	10	1.8
30 mm PP*	No	6	1
None	Yes	10 - 50	1.8 - 10
10 mm PP*	Yes	3 - 10	0.5 - 1.8

*Polypropylen insulation with $k = 0.167 \text{ W/mK}$

**Buried depends on the quality of the soil, in addition to the depth. If water is present, a lower insulation effect, and a higher heat transfer coefficient result. A typical value for wells is $10 \text{ W/m}^2\text{K}$, so a lower value will usually not be obtainable only with soil. If insulation is used in combination with a buried pipe, a very low heat transfer coefficient can be obtained. Use $50 \text{ W/m}^2\text{K}$ for non-insulated pipelines, and $10\text{-}20 \text{ W/m}^2\text{K}$ for buried pipelines for which no temperature data are available.

With regard to the roughness parameter, it is suggested that the default value of 0.00005 m (0.000015 ft) provided by the model be used. This is a typical value for carbon steel pipelines. Corrosion will of course increase the resistance, but this is difficult to account for in a general sense. The roughness coefficient should generally be between 0.00025 and 0.0000025 m (0.000076 and 0.00000076 ft).

The Petroleum Engineering Handbook supplies the following guidelines for the roughness coefficient:

Absolute Pipe Roughness, New Pipe	Inches	m
Unlined concrete	0.1000	0.00254000
Unlined concrete, fine	0.0100	0.00025400
Cast iron	0.0100	0.00025400
Galvanized iron	0.0060	0.00015240
Carbon steel	0.0018	0.00004572
Fiberglass epoxy	0.0003	0.00000762
Drawn tubing	0.0001	0.00000254

3 Discharge calculation

3.1 Calculate discharge

After creating your analysis scenario, select Scenario menu\Verify Layout (or the Network Check button on the toolbar). This checks a number of potential problems in the network layout, such as:

- Missing or invalid object parameters,
- Outlet point connected to more than one in-coming branch,
- Pipeline segment shorter than depth difference between endpoints,
- Maximum number of objects exceeded (100 pipeline segments, 5 junction, 10 segments per junction), and
- More than one leakage point found.

In general, these messages are self explanatory, and lead the user quickly to the problem area.

If the “valid network” message appears one can continue with the analysis. Otherwise the message-box identifies the problem.

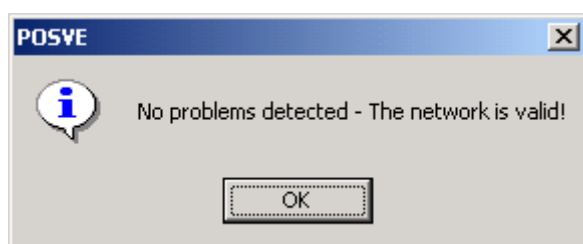


Figure 3.1 Corresponding message-box gives you the status of your analysis-scenario.

Shortcut: Select Calculate Discharge from the Scenario menu (or Worst case discharge button on the toolbar), automatically runs the Verify Layout test prior to estimating the discharge for the given scenario.

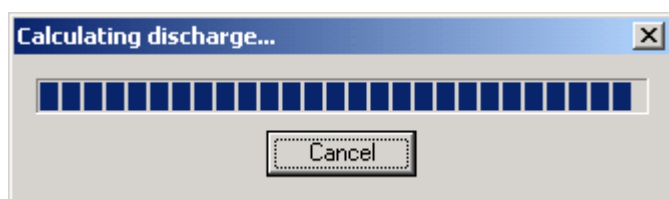


Figure 3.2 The progress bar allows you to follow the calculation process.

3.2 View discharge output

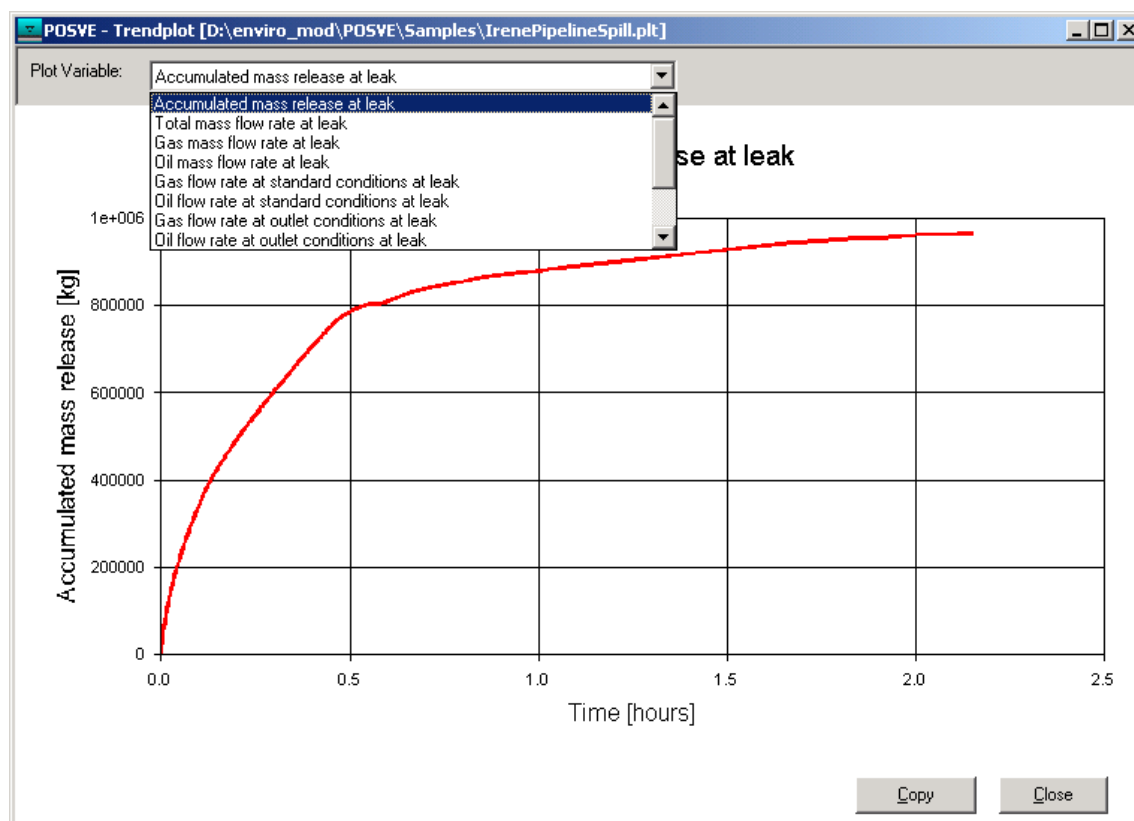
A Discharge Summary appears at completion of the discharge calculation, and is also accessible via the Result menu.

Discharge Summary

Time to get total mass: min
 - equivalent to hours days

Peak rates		Totals	
Mass:	<input type="text" value="3.7e+003"/> kg/s	Mass:	<input type="text" value="9.64e+005"/> kg
Oil:	<input type="text" value="5.2e+004"/> m3/d	Oil:	<input type="text" value="157"/> m3
Gas:	<input type="text" value="0.0248"/> Mm3/d	Gas:	<input type="text" value="125"/> m3
Oil (std.cond):	<input type="text" value="5.19e+004"/> Sm3/d	Oil (std.cond):	<input type="text" value="156"/> Sm3
Gas (std.cond):	<input type="text" value="0.267"/> MSm3/d	Gas (std.cond):	<input type="text" value="806"/> Sm3

Warnings:



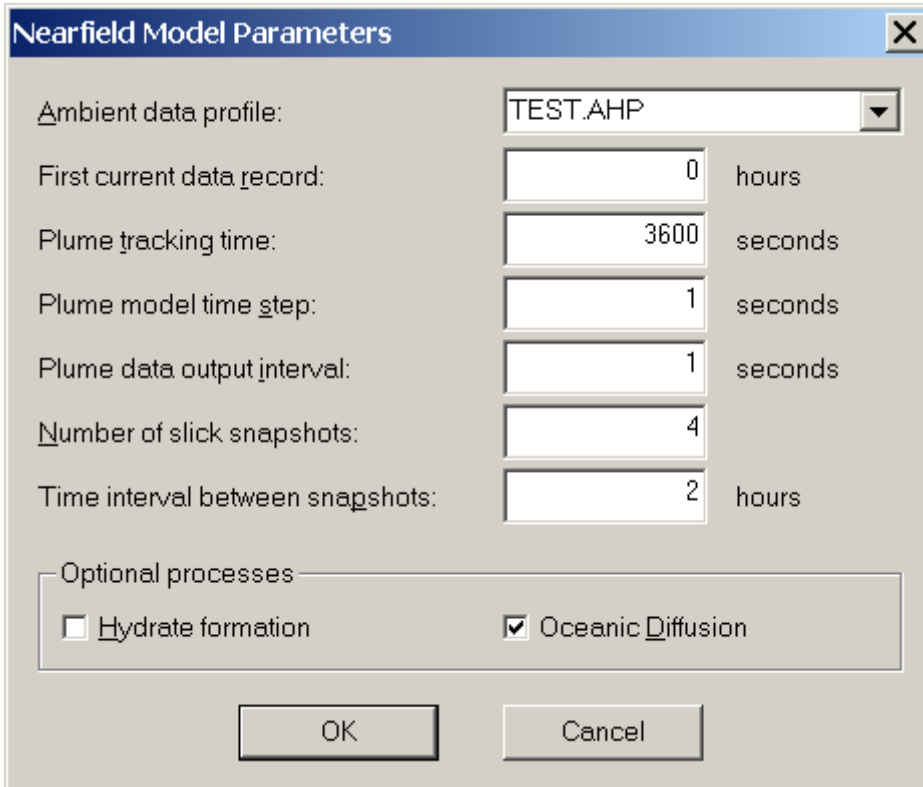
4 Nearfield Module

4.1 Module setup

The Nearfield Module consists of two models linked together in a single program, the oil and gas plume simulation model *DeepBlow* and the *Surfacing* model simulating the formation of surface slicks from oil droplets escaping from the plume. The two models are described in detail in the Technical Documentation of the MMS-POSVCM.

The Release module must be run before the Nearfield module, since the latter uses results from the former to compute the thickness of oil at the sea surface. To set up the Nearfield module, select the menu item Scenario, Nearfield Setup (Figure 7.1).

The Nearfield setup allows the user to specify a start time in the velocity files, duration for the time series computation of the Nearfield plume, the computational time step, the output interval, the number of snapshots to be recorded, and the time interval between snapshots. These parameters are explained below.



The image shows a Windows-style dialog box titled "Nearfield Model Parameters". It contains several input fields and checkboxes. The "Ambient data profile" is a dropdown menu set to "TEST.AHP". The "First current data record" is a text box with "0" and the unit "hours". The "Plume tracking time" is a text box with "3600" and the unit "seconds". The "Plume model time step" is a text box with "1" and the unit "seconds". The "Plume data output interval" is a text box with "1" and the unit "seconds". The "Number of slick snapshots" is a text box with "4". The "Time interval between snapshots" is a text box with "2" and the unit "hours". At the bottom, there is a section for "Optional processes" with two checkboxes: "Hydrate formation" (unchecked) and "Oceanic Diffusion" (checked). "OK" and "Cancel" buttons are at the bottom.

Parameter	Value	Unit
Ambient data profile	TEST.AHP	-
First current data record	0	hours
Plume tracking time	3600	seconds
Plume model time step	1	seconds
Plume data output interval	1	seconds
Number of slick snapshots	4	-
Time interval between snapshots	2	hours

Optional processes:

- ☐ Hydrate formation
- ☒ Oceanic Diffusion

Figure 7.1 Nearfield setup menu.

Description of entries in Nearfield Setup:

Ambient Hydrographic Profile (AHP): The Nearfield module requires as input vertical profiles for current, water temperature and salinity. These data are read in from three files located in the folder Ambient under the installation folder for the MMS-POSVCM. These files must be supplied by the user for the area of application. (The files supplied with the model are from the Norwegian Sea, and are given to exemplify the format required.) The formats for these text files are given in

Figure 7.2. The AHP file contains depth in the first column, temperature (degrees C) in the second, and salinity (‰) in the third.

The Ambient Hydrographic Profile (*profile_name.AHP*) must be accompanied by two Ambient Current files, one for the east component (*profile_name.ACE*) and one for the north component (*profile_name.ACN*). The format and content of these files is shown and explained in Figure 7.2.

First current data record: Determines the number of hours from the beginning of the current record to start the simulation.

Plume tracking time: Specifies the number of seconds to track the plume. Longer times are necessary for deeper waters and weaker source strengths. If the oil does not come to the surface, try a longer tracking time. Note that oil may never come to the surface if the release produces very small droplets.

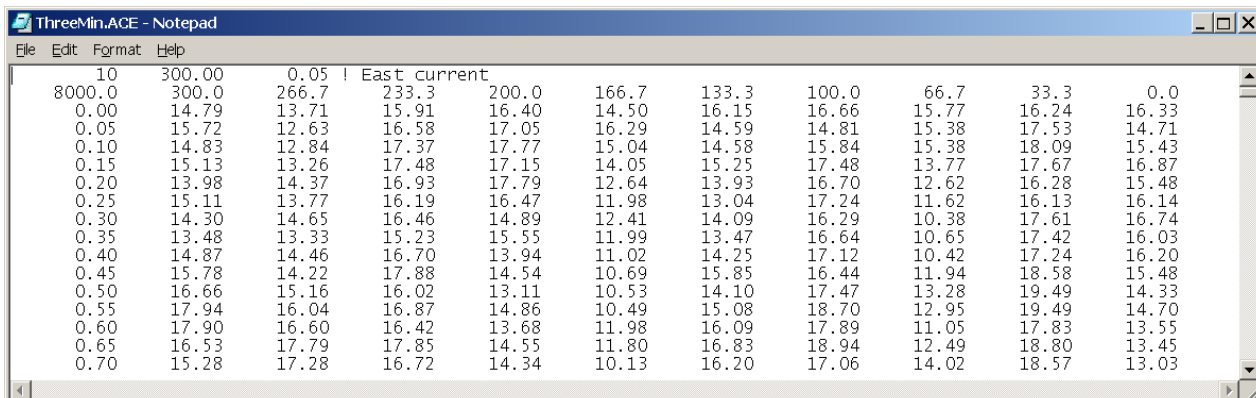
Plume model timestep: Default of 1 second is usually OK.

Plume data output interval: Determines how often during the tracking time the plume formation data will be recorded. Note that the first snapshot occurs at completion of the release itself.

Number of slick snapshots: Specifies number of snapshots of the surface slick to be recorded. The first snapshot occurs at the conclusion of the release, and time is counted from then.

Time interval between snapshots: Number of hours between subsequent snapshots.

The distribution of oil thickness at the sea surface, as computed by the Nearfield module, is found in the file *scenario.COT*. This file can be imported into a spreadsheet program to display a gridded map of the surface slick thickness.

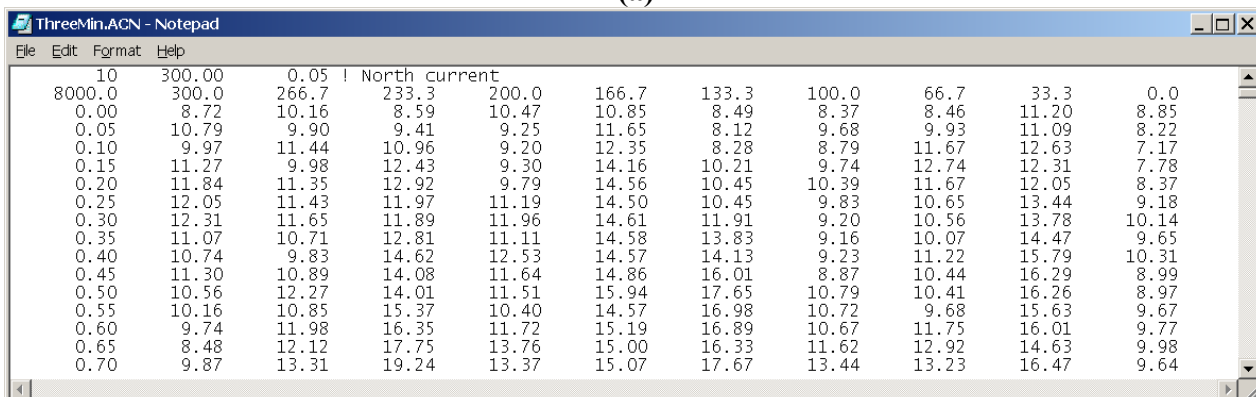


ThreeMin.ACE - Notepad

File Edit Format Help

10	300.00	0.05	East current							
8000.0	300.0	266.7	233.3	200.0	166.7	133.3	100.0	66.7	33.3	0.0
0.00	14.79	13.71	15.91	16.40	14.50	16.15	16.66	15.77	16.24	16.33
0.05	15.72	12.63	16.58	17.05	16.29	14.59	14.81	15.38	17.53	14.71
0.10	14.83	12.84	17.37	17.77	15.04	14.58	15.84	15.38	18.09	15.43
0.15	15.13	13.26	17.48	17.15	14.05	15.25	17.48	13.77	17.67	16.87
0.20	13.98	14.37	16.93	17.79	12.64	13.93	16.70	12.62	16.28	15.48
0.25	15.11	13.77	16.19	16.47	11.98	13.04	17.24	11.62	16.13	16.14
0.30	14.30	14.65	16.46	14.89	12.41	14.09	16.29	10.38	17.61	16.74
0.35	13.48	13.33	15.23	15.55	11.99	13.47	16.64	10.65	17.42	16.03
0.40	14.87	14.46	16.70	13.94	11.02	14.25	17.12	10.42	17.24	16.20
0.45	15.78	14.22	17.88	14.54	10.69	15.85	16.44	11.94	18.58	15.48
0.50	16.66	15.16	16.02	13.11	10.53	14.10	17.47	13.28	19.49	14.33
0.55	17.94	16.04	16.87	14.86	10.49	15.08	18.70	12.95	19.49	14.70
0.60	17.90	16.60	16.42	13.68	11.98	16.09	17.89	11.05	17.83	13.55
0.65	16.53	17.79	17.85	14.55	11.80	16.83	18.94	12.49	18.80	13.45
0.70	15.28	17.28	16.72	14.34	10.13	16.20	17.06	14.02	18.57	13.03

(a)

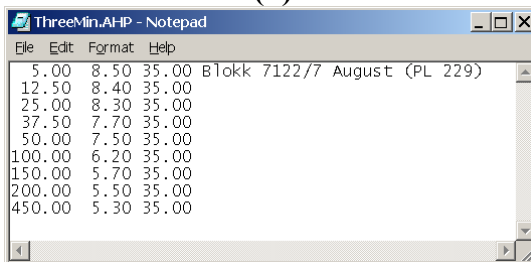


ThreeMin.ACN - Notepad

File Edit Format Help

10	300.00	0.05	North current							
8000.0	300.0	266.7	233.3	200.0	166.7	133.3	100.0	66.7	33.3	0.0
0.00	8.72	10.16	8.59	10.47	10.85	8.49	8.37	8.46	11.20	8.85
0.05	10.79	9.90	9.41	9.25	11.65	8.12	9.68	9.93	11.09	8.22
0.10	9.97	11.44	10.96	9.20	12.35	8.28	8.79	11.67	12.63	7.17
0.15	11.27	9.98	12.43	9.30	14.16	10.21	9.74	12.74	12.31	7.78
0.20	11.84	11.35	12.92	9.79	14.56	10.45	10.39	11.67	12.05	8.37
0.25	12.05	11.43	11.97	11.19	14.50	10.45	9.83	10.65	13.44	9.18
0.30	12.31	11.65	11.89	11.96	14.61	11.91	9.20	10.56	13.78	10.14
0.35	11.07	10.71	12.81	11.11	14.58	13.83	9.16	10.07	14.47	9.65
0.40	10.74	9.83	14.62	12.53	14.57	14.13	9.23	11.22	15.79	10.31
0.45	11.30	10.89	14.08	11.64	14.86	16.01	8.87	10.44	16.29	8.99
0.50	10.56	12.27	14.01	11.51	15.94	17.65	10.79	10.41	16.26	8.97
0.55	10.16	10.85	15.37	10.40	14.57	16.98	10.72	9.68	15.63	9.67
0.60	9.74	11.98	16.35	11.72	15.19	16.89	10.67	11.75	16.01	9.77
0.65	8.48	12.12	17.75	13.76	15.00	16.33	11.62	12.92	14.63	9.98
0.70	9.87	13.31	19.24	13.37	15.07	17.67	13.44	13.23	16.47	9.64

(b)



ThreeMin.AHP - Notepad

File Edit Format Help

Blok 7122/7 August (PL 229)			
5.00	8.50	35.00	
12.50	8.40	35.00	
25.00	8.30	35.00	
37.50	7.70	35.00	
50.00	7.50	35.00	
100.00	6.20	35.00	
150.00	5.70	35.00	
200.00	5.50	35.00	
450.00	5.30	35.00	

(c)

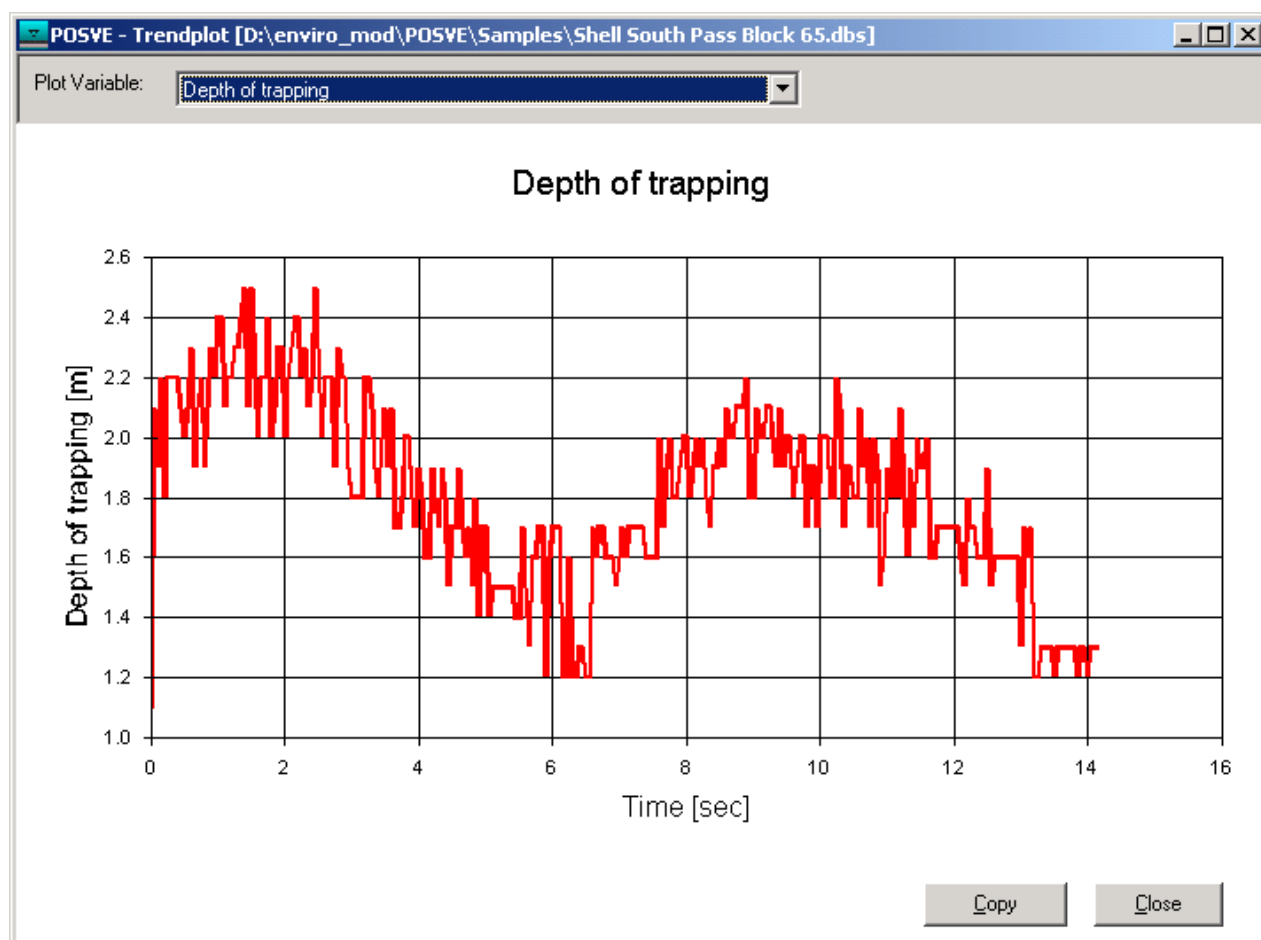
Figure 7.2 Input file formats for vertical current and hydrographic data for the Nearfield module. Figures (a) and (b) show the North and East velocity component files. The first row gives the number of depth intervals (10 in this example), the total depth (300 m here), and the time step between subsequent records (0.05 hr, or 3 min here). The second row is the start time in Excel format of the actual measured vertical time series, with time in hours from the reference date January 1, 1900, in the first column, and the depths of the measurements following. (Time since 01-01-1900 is not used in the calculations, but may be used to identify the actual time when the time series was recorded.) Subsequent records are the time (hrs) and associated current magnitudes (cm/sec) at each depth.

4.2 View Nearfield output

4.2.1 Time series plots

Time series results from the Nearfield module are available under the menu item Result/Nearfield plot. Quantities available are

- Depth of trapping (m)
- Distance East or North (m)
- Plume radius (m)
- Horizontal and vertical velocities (cm/s)
- Source strength (m²/s)
- 95th percentile droplet size (mm)
- Rise time (sec)
- Oil concentration (ppm)
- Remaining fraction of gas (%)
- Dissolved fraction of oil (%)
- Fraction of gas in hydrate (%)

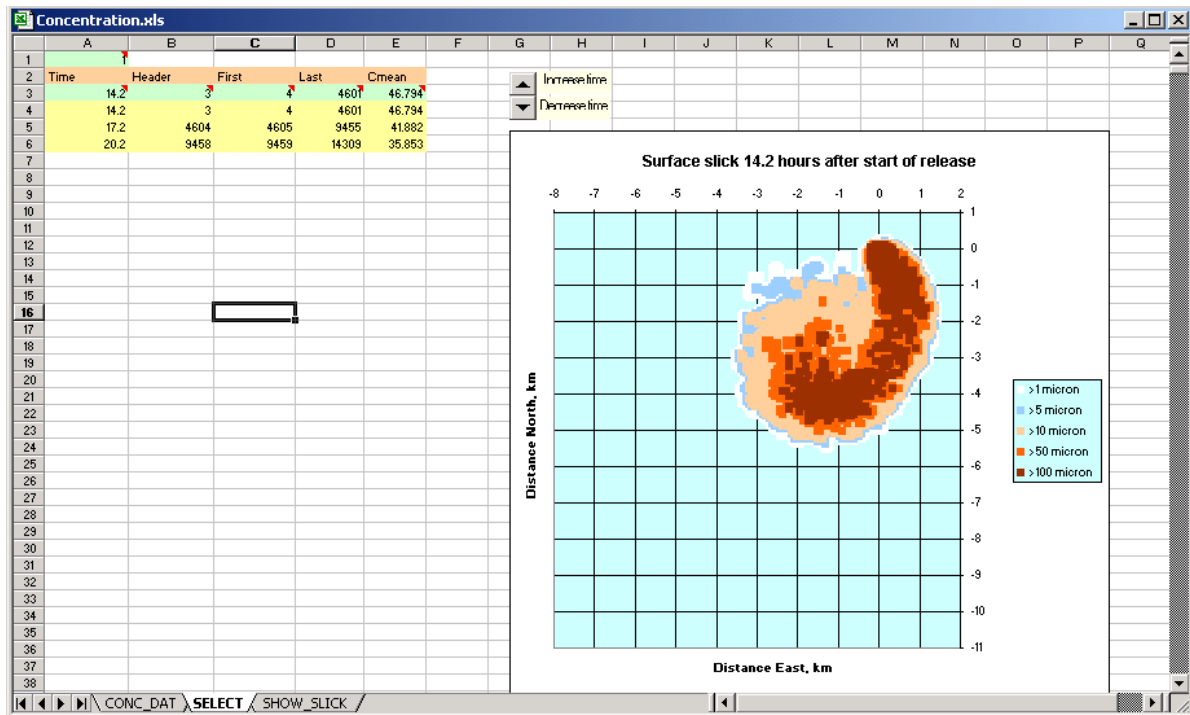


4.2.2 Surface distribution of oil

A spreadsheet file, Concentration.xls, is supplied to assist in plotting 2-dimensional distributions of oil on the sea surface. Both the discharge and nearfield modules must have been run prior to viewing surface thickness distributions.

Upon opening, Concentration.xls prompts the user for an input file (scenario.COT) produced by running the nearfield module. After selection, the embedded macros will load the data from the

file. This may take a little time, depending on how often data was specified to be saved in the scenario Nearfield setup. To load a new file, use the toolbar button "load file...."



The surface plot for the first timestep stored will appear on the worksheet "Select". To advance the surface plot in time, use the up arrow on the spreadsheet. Use the down-arrow to plot an earlier time. The available times are shown in the time-box in the upper left corner of the spreadsheet.

To adjust the thickness key, change value of the parameter Cmin at the top of the worksheet "Show Slick". Then click the "Set value" button to the right to register the new value in the data set.

4.3 Content of output files from Nearfield module

scenario.DBS

Summary of results from plume simulation.

Parameter	Unit	Explanation
HOURL	hours	Start time of individual plume simulations with reference to times in the current data record
H	m	Depth corresponding to maximum plume rise (Depth of Trapping, DOT)
X	m	East displacement of plume at DOT
Y	m	North displacement of plume at DOT
R	m	Plume radius at DOT
U	cm/s	Horizontal component of plume velocity at DOT
W	cm/s	Vertical component of plume velocity at DOT
Str	m ² /s	Source strength, measure of surface spreading rate for surfacing plumes
D95	mm	95% maximum droplet size formed at exit
Time	seconds	Rise time to DOT
ppm	1.e-6	Oil concentration in plume at DOT
%G	%	Mass fraction of gas remaining as gas bubbles at DOT
%D	%	Mass fraction of gas dissolved in plume at DOT
%H	%	Mass fraction of gas in hydrate at DOT

scenario.DBP

Data on individual plume trajectories.

Repeated for each plume, separated by one line.

Parameter	Unit	Explanation
First column	hours	First row in sequence: Start time in hours of individual plume simulations with reference to times in the current data record.
	seconds	Subsequent rows: Rise time in seconds from start of plume trajectory. Note: Time intervals determined in user interface.
X	m	East displacement of plume centerline
Y	m	North displacement of plume centerline
H	m	Depth of plume centerline
R	m	Plume radius
U	cm/s	Horizontal component of plume velocity
W	cm/s	Vertical component of plume velocity
T	°C	Temperature in plume
S	1.e-3	Salinity in plume
ppm	1.e-6	Oil concentration in plume
Gas	%	Mass fraction of gas remaining as gas bubbles
Diss	%	Mass fraction of gas dissolved in plume
Hydrate	%	Mass fraction of gas in hydrate

scenario.COS

Summary data for surface slicks

Parameter	Unit	Explanation
Time	hours	Time from start of release
Qrel	m ³	Released oil volume
Qsurf	m ³	Surfaced oil volume
%	%	Volume fraction of oil surfaced
Microns	1.e-6 m	Average thickness of surface slick

scenario.COT

Distribution of film thickness in surface slick at different times after release (snapshots)

First snapshot at end time of release. Sequence repeated for each snapshot, separated by blank line.

Parameter	Unit	Explanation
First row in sequence	hours	Text including time of the snapshot in hours from start of release
Second row in sequence		1 – 4 th column: Column headers in sequence
		5 th column: Time from start, hours
		6 th column: Number of rows in sequence
		7 th column: Average surface film thickness, microns
NCL	m	Cell number
km_East	m	Distance of cell east of discharge point
km_North	m	Distance of cell north of discharge point
microns	1.e-6 m	Oil film thickness in cell

Example of file *scenario.DBS*: Summary of results from plume simulation

HOURL	H	X	Y	R	U	W	Str	D95	Time	ppm	%G	%D	%H
120.0	10.7	46.7	-27.6	34.7	11.1	35.0	268.7	3.6	583.0	38.9	55.0	22.1	0.0
120.5	6.5	45.4	-22.6	29.6	12.7	60.1	387.7	3.1	475.0	18.5	72.2	20.6	0.0
121.0	8.6	56.7	-19.7	31.5	15.6	55.1	381.9	3.4	475.0	10.7	66.7	20.3	0.0
121.5	17.0	74.4	-14.7	38.8	18.2	37.8	333.1	3.7	502.0	7.6	55.5	20.1	0.0
122.0	35.3	98.3	-4.6	48.2	21.8	20.4	256.5	4.1	541.0	5.9	39.0	19.7	0.0
122.5	45.7	110.9	10.8	51.7	24.0	13.0	210.3	4.5	571.0	4.8	31.6	19.9	0.0
123.0	53.9	133.9	32.1	54.2	25.4	2.6	95.7	4.9	650.0	4.0	19.2	20.0	0.0
123.5	93.7	682.2	375.2	95.5	27.4	5.4	253.9	5.4	3023.0	1.0	0.0	24.2	0.0
124.0	74.3	140.2	71.9	50.6	27.7	0.0	0.0	6.0	694.0	3.2	11.6	19.0	0.0
124.5	81.4	137.3	92.8	48.8	28.7	0.0	0.0	6.6	712.0	3.0	9.1	18.4	0.0
125.0	91.9	132.4	117.6	47.0	28.4	0.0	0.0	7.3	758.0	2.9	5.5	16.7	0.0
125.5	100.1	125.2	135.6	46.1	27.7	0.0	0.0	8.0	798.0	2.7	3.8	16.1	0.0
126.0	106.3	105.0	149.5	44.4	27.9	0.0	0.0	8.9	803.0	2.5	3.1	15.3	0.0
126.5	113.7	83.9	156.6	42.8	26.4	0.0	0.0	9.9	815.0	2.5	2.2	13.8	0.0
127.0	123.8	60.1	160.3	41.9	24.1	0.0	0.0	11.3	845.0	2.5	1.4	12.0	0.0
127.5	216.1	9.9	366.3	33.7	18.2	0.0	0.0	11.7	1913.0	1.5	0.0	3.7	0.0
128.0	267.0	-235.0	613.2	11.1	20.8	0.0	0.0	11.7	3223.0	2.2	0.0	0.2	0.0
128.5	276.0	-296.1	482.4	7.7	18.4	0.0	0.0	11.7	3121.0	1.8	0.0	0.0	0.0

Example of *scenario.DBP*: Data on individual plume trajectories

Note: Only first two sequences shown.

	X	Y	H	R	U	W	T	S	ppm	Gas	Diss	Hydr
120	0.1	-0.1	296.8	0.6	11.2	99.7	5.5	35.0	49450.8	100.0	0.0	0.0
1	0.1	-0.1	296.8	0.6	11.2	99.7	5.5	35.0	49450.8	100.0	0.0	0.0
60	2.9	-4.9	251.3	6.1	7.0	63.4	5.4	35.0	732.2	96.5	3.5	0.0
120	5.1	-8.1	216.2	10.1	6.8	55.1	5.5	35.0	301.8	93.4	6.6	0.0
180	7.8	-12.0	184.3	13.5	9.0	51.9	5.5	35.0	179.6	90.4	9.5	0.0
240	11.5	-16.8	153.9	16.7	10.9	49.4	5.5	35.0	122.1	85.4	12.2	0.0
300	16.5	-21.0	124.7	19.7	10.6	47.8	5.6	35.0	91.1	79.3	14.6	0.0
360	22.1	-23.9	96.6	22.5	10.6	46.0	5.7	35.0	71.8	73.8	16.7	0.0
420	28.3	-25.8	70.1	26.6	11.1	41.6	5.9	35.0	56.8	69.3	18.6	0.0
480	35.1	-26.8	46.8	31.0	11.5	36.6	6.1	35.0	46.7	64.4	20.2	0.0
540	41.9	-27.3	25.5	33.6	11.3	34.6	6.3	35.0	41.9	58.6	21.4	0.0
120.5	X	Y	H	R	U	W	T	S	ppm	Gas	Diss	Hydr
1	0.1	-0.1	296.5	0.7	13.0	109.1	5.5	35.0	22301.6	100.0	0.0	0.0
60	4.3	-5.1	245.9	6.7	8.8	70.8	5.4	35.0	308.9	96.4	3.6	0.0
120	8.0	-8.5	206.5	11.2	8.8	62.0	5.5	35.0	126.0	93.2	6.8	0.0
180	12.1	-12.7	170.4	14.9	10.8	59.0	5.5	35.0	74.2	90.2	9.8	0.0
240	17.4	-17.1	135.5	18.4	11.7	57.3	5.6	35.0	50.4	86.5	12.5	0.0
300	23.8	-19.9	101.6	21.7	11.7	55.9	5.7	35.0	36.8	82.6	15.1	0.0
360	30.8	-21.6	68.5	25.2	12.4	54.0	5.9	35.0	28.3	78.8	17.3	0.0
420	38.4	-22.4	36.7	28.4	12.8	53.0	6.2	35.0	22.6	74.8	19.2	0.0

Example of *scenario.COS*: Partitioning of oil between water surface and water column

Note that dissolution is not accounted for in this partitioning, which is based solely on computed droplet size distribution for the given scenario.

RELEASE START AT CURRENT RECORD TIME, hrs: 120.0

RELEASE DURATION, hrs: 9.0

Time	Qrel	Qsurf	%	Microns
9	429.8	429.1	99.9	39.1
10	429.8	429.7	100.0	30.3
11	429.8	429.8	100.0	27.3
12	429.8	429.8	100.0	25.1
13	429.8	429.8	100.0	22.9
14	429.8	429.8	100.0	20.0

Example of *scenario.COT* : Distribution of film thickness in surface slicks.

Note: Only parts of first sequence shown.

CONCENTRATIONS_AT_TIME, _hours: 9.0

NCL	km_East	km_North	microns	9	482	39.1
1	-0.188	0.747	2.680			
2	-0.037	0.747	36.447			
3	0.114	0.747	5.310			
4	-0.188	0.898	2.168			
5	-0.037	0.898	38.307			
6	0.114	0.898	4.877			
7	0.265	0.898	0.105			
8	-0.188	1.049	0.450			
9	-0.037	1.049	0.829			
10	0.114	1.049	0.886			
11	0.265	1.049	0.574			
12	0.416	1.049	0.120			

5 Table of Conversions

To convert from	To	Multiply by
m	in	39.37
m	ft	3.281
ft	in	12
Bar	Psi	14.504
Bar	Pascals	100,000
°F	°C	$(T_F - 32) 0.5556$
°C	°F	$1.8 T_C + 32$
Sm ³ / Sm ³	Scf/bbl	5.615
lb/ft ³	Specific gravity [-]	0.01602
kg/m ³	lb/ft ³	0.06243
kg/m ³	Specific gravity [-]	0.001
Specific gravity [-]	API gravity [-]	$(141.5/\text{Specific gravity}) - 131.5$
kg/m ³	Gas gravity [-]	1/1.234

6 Example Test Cases

Open an empty scenario window and fill in objects with properties as described in the properties table below, and connect them as shown in Figure 6.1. Then click the POSVCM discharge button on the toolbar (or the F5 function key), and compare model results with those shown in Figure 6.2. A more complicated scenario is demonstrated in Figures 6.3 and 6.4.

(Note: shorten the Torch Line to 30600 ft to get the result shown here, which reflects the closure of the pipeline on the downstream side of the leak due to a pig stuck in the line.)

6.1 Example scenario 1: Irene Pipeline Spill

Fluid properties:

Gas density:	lb/scf	0.06
Oil density	ppg	6.7
Gas-Oil Ratio	scf/stb	30
Percent water in fluid	%	84

Flow inlet properties:

Depth	ft	40
Total liquid flow rate	stbd	66719.8
Fluid temperature	°F	120
Closing time	min	25

Pipeline 1: "Riser"

Length	ft	284.01
Inside diameter	in	18.622
Roughness coefficient:	ft	0.000164042
Heat transfer coefficient:	BTU/ft ² h°F	0.176772
Ambient temperature	°F	50

Pipeline 2: "Torch 20-inch line"

Length	ft	63000
Inside diameter	in	18.6
Roughness coefficient:	ft	0.00016
Heat transfer coefficient:	BTU/ft ² h°F	0.1768
Ambient temperature	°F	50

Pipe connector or junction:

Depth	ft	244
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Outlet:

Depth	ft	120
Fluid pressure	psi	680
Closing time	min	0

Leak properties:

Distance from upstream endpoint	ft	30578
Nominal diameter	in	18.6
Water depth.	ft	122

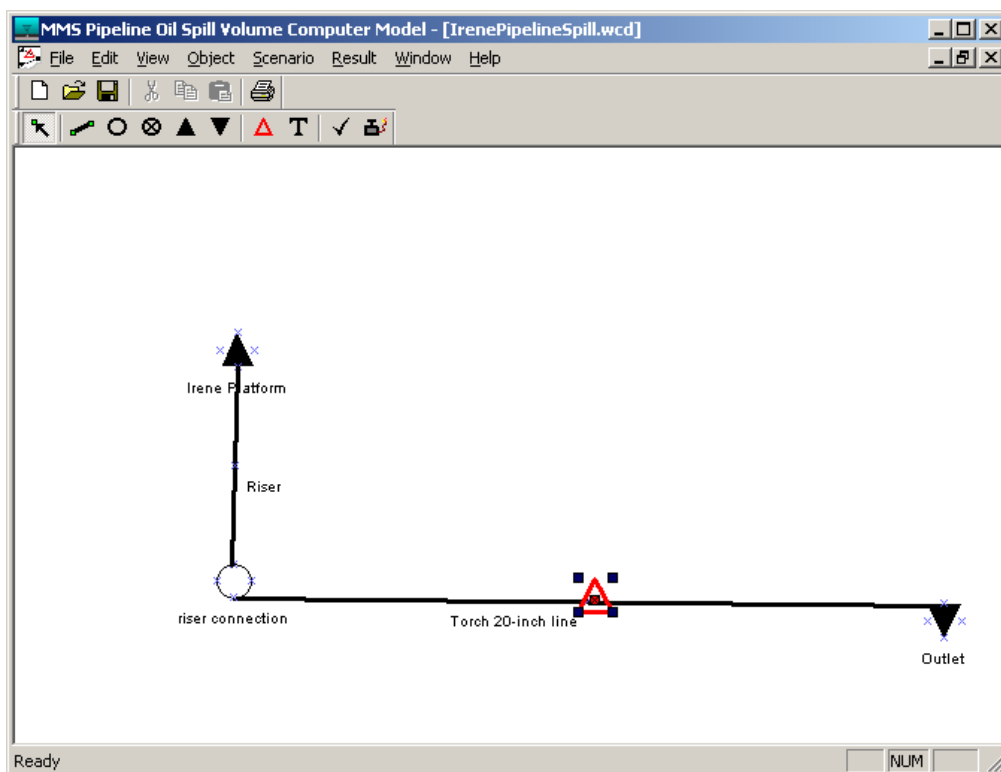


Figure 6.1 Graphical description of the layout for the Irene Pipeline Spill.

Discharge Summary					
Time to get total mass:		56.95	min		
- equivalent to		0.95	hours		
		0.04	days		
Peak rates		Totals			
Mass:	5.92e+003	lb/s	Mass:	5.59e+005	lb
Oil:	2.37e+005	bpd	Oil:	259	bbl
Gas:	0.833	mmcf/d	Gas:	2.36e+003	ft ³
Oil (std. cond):	2.37e+005	stbd	Oil (std. cond):	259	stb
Gas (std. cond):	6.85	mmscfd	Gas (std. cond):	7.49e+003	scf
Warnings					
Close					

Figure 6.2 Result window for the Irene Pipeline Spill.

6.2 Example scenario 2: Chevron South Pass

Fluid properties:

Gas density:	lb/scf	0.062
Oil density	ppg	6.7
Gas-Oil Ratio	scf/stb	25
Percent water in fluid	%	80

Flow inlet: Cusa Platforms MC 49A,B,C

Depth	ft	-82
Total liquid flow rate	stbd	6289.81
Fluid temperature	°F	140
Closing time	min	60

Pipeline: “riser”

Length	ft	1312
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	41

Pipe connector or junction:

Depth	ft	393.70
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Pipeline: “Pipe 10” Line to Cusa”

Length	ft	39370
Inside diameter	in	9.842
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.176772
Ambient temperature	°F	68

Flow inlet: Taylor Platform MC20

Depth	ft	-82
Total liquid flow rate	stbd	628.98
Fluid temperature	°F	140
Closing time	min	60

Pipeline: “riser”

Length	ft	656
Inside diameter	in	7.87
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	41

Pipe connector or junction:

Depth	ft	393.70
-------	----	--------

Pipeline: “8” line to Taylor”

Length	ft	53234
Inside diameter	in	7.87
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.176772
Ambient temperature	°F	41

Pipe junction:

Depth	ft	393.7
-------	----	-------

Pipeline: "Pipe 10" Line upstream from BP"

Length	ft	3280
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	68

Flow inlet: BP Platform MC109

Depth	ft	-82
Total liquid flow rate	stbd	10296.4
Fluid temperature	°F	140
Closing time	min	60

Pipeline: "riser"

Length	ft	656
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	41

Pipe connector or junction:

Depth	ft	393.70
-------	----	--------

Pipeline: "10" line to BP"

Length	ft	38753.3
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	68

Pipe junction:

Depth	ft	393.7
-------	----	-------

Pipeline: " Pipe 10" Line Upstream from BP "

Length	ft	65616.8
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	68

Flow inlet : OXY Platform SP 45

Depth	ft	-82
Total liquid flow rate	stbd	188.69
Fluid temperature	°F	140
Closing time	min	60

Pipeline: " 4" line to OXY "

Length	ft	4717.85
Inside diameter	in	3.93
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	68

Pipe junction:

Depth	ft	131.23
-------	----	--------

Pipeline: " Pipe 10" Line to Outlet"

Length	ft	36417.3
Inside diameter	in	9.84
Roughness coefficient:	ft	0.000164
Heat transfer coefficient:	BTU/ft ² h°F	0.1767
Ambient temperature	°F	68

Outlet: " on shore"

Depth	ft	-50
Fluid pressure	psi	36.706
Closing time	min	0

Leak properties:

Distance from upstream endpoint	ft	16404.2
Nominal diameter	in	9.84
Water depth.	ft	131.23

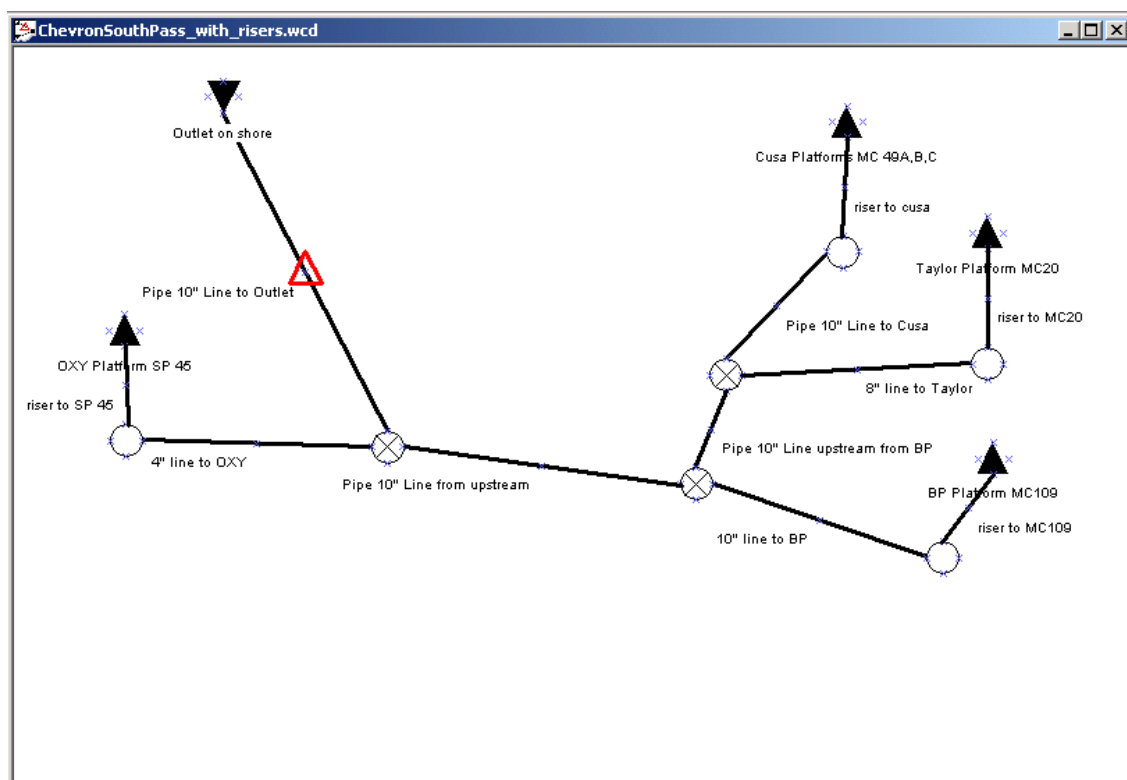


Figure 6.3 Graphical description of the Chevron South Pass Spill.

Discharge Summary			
Time to get total mass:		86.25	min
- equivalent to		1.44	hours
		0.06	days
Peak rates			
Mass:	868	lb/s	
Oil:	4.43e+004	bpd	
Gas:	0.437	mmcf/d	
Oil (std.cond):	4.38e+004	stbd	
Gas (std.cond):	1.04	mmscfd	
Totals			
Mass:	1.8e+005	lb	
Oil:	106	bbl	
Gas:	1.12e+003	ft3	
Oil (std.cond):	105	stb	
Gas (std.cond):	2.5e+003	scf	
Warnings			
Close			

Figure 6.4 Result window for the Chevron South Pass Spill